CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus for controlling the temperature of a reaction mixture, the apparatus comprising:

   a) a reaction vessel having a chamber for holding the mixture, the vessel comprising:

      i) a rigid frame defining the side walls of the chamber, wherein the frame further includes a port and a channel connecting the port to the chamber; and

      ii) at least one flexible sheet attached to the rigid frame to form a major wall of the chamber;

   b) at least one thermal surface for contacting the major wall;

   c) an automated machine for increasing the pressure in the chamber, wherein the pressure increase in the chamber is sufficient to force the major wall to contact and conform to the thermal surface; and

   d) at least one thermal element for heating or cooling the surface to induce a temperature change within the chamber.

2. The apparatus of claim 1, wherein the vessel includes first and second flexible sheets attached to opposite sides of the rigid frame to form opposing major walls of the chamber, the apparatus includes first and second thermal surfaces formed by opposing plates positioned to receive the chamber between them, and the pressure increase in the chamber is sufficient to force the major walls to contact and conform to the inner surfaces of the plates.

3. The apparatus of claim 2, wherein each of the plates comprises a ceramic material, and wherein each of the plates has a thickness less than or equal to 1 mm.

4. The apparatus of claim 2, wherein each of the plates has a resistive heating element coupled thereto.

5. The apparatus of claim 4, wherein the heating element comprises a film.

6. The apparatus of claim 2, wherein each of the plates has a thermal mass less than 5 J/°C.

7. The apparatus of claim 2, wherein each of the plates has a thermal mass less than 3 J/°C.

8. The apparatus of claim 2, wherein each of the plates has a thermal mass less than 1 J/°C.

9. The apparatus of claim 2, further comprising a support structure for holding the plates in an opposing relationship to each other, the support structure comprising:

a) a mounting plate having a slot therein;

b) spacing posts extending from the mounting plate on opposite sides of the slot, wherein each of the spacing posts has indentations formed on opposite sides thereof for receiving the edges of the plates; and

c) retention clips for holding the edges of the plates in the indentations.

10. The apparatus of claim 1, wherein the automated machine comprises a pick-and-place machine for inserting a plunger into the channel to compress gas in the vessel and thereby increase the pressure in the chamber.

11. The apparatus of claim 10, wherein the frame includes an inner surface defining the channel, and wherein the inner surface has at least one pressure control groove

formed therein, the pressure control groove extending to a predetermined depth in the channel to allow gas to escape from the vessel until the plunger reaches the predetermined depth.

12. The apparatus of claim 10, wherein the plunger has a pressure stroke sufficient to increase the pressure in the chamber to at least 2 psi above the ambient pressure external to the vessel.

13. The apparatus of claim 1, wherein the automated machine comprises:

a) a machine head having an axial bore for communicating with the channel of the vessel; and

b) a pressure source for pressurizing the chamber through the bore in the machine head.

14. The apparatus of claim 13, further comprising an adapter for placing the bore in fluid communication with the channel, wherein the adapter is sized to be inserted into the channel such that the adapter establishes a seal with the walls of the channel.

15. The apparatus of claim 14, wherein the adapter includes a valve for preventing fluid from escaping from the vessel.

16. The apparatus of claim 1, further comprising an elastomeric plug inserted into the channel, wherein the automated machine comprises:

a) means for inserting a needle through the plug; and

b) a pressure source for injecting fluid into the vessel through the needle.

17. The apparatus of claim 16, wherein the needle includes a first bore for dispensing the fluid into the vessel and a second bore for venting gas from the vessel, and wherein the first bore has a length greater than the second bore.

18. The apparatus of claim 1, wherein the automated machine comprises a platen for heat sealing a film or foil to the vessel to seal the port and reduce the volume of the channel.

19. The apparatus of claim 1, wherein:

a) at least two of the side walls of the chamber are optically transmissive and angularly offset from each other;

b) the apparatus further comprises an optics system having at least one light source for exciting the mixture through a first one of the optically transmissive side walls and having at least one detector for detecting light emitted from the chamber through a second one of the optically transmissive side walls.

20. The apparatus of claim 19, wherein:

a) the apparatus includes first and second thermal surfaces formed by opposing plates positioned to receive the chamber of the vessel between them; and

b) each of the plates has first and second edges angularly offset from each other by substantially the same angle that the optically transmissive side walls are offset from each other, and the plates are positioned to receive the chamber between them such that the first optically transmissive side wall is positioned substantially adjacent and parallel to the first bottom edge of each plate and such that the second optically transmissive side wall is positioned substantially adjacent and parallel to the second bottom edge of each plate.

21. The apparatus of claim 19, wherein the optically transmissive side walls are angularly offset from each other by about 90°.

22. The apparatus of claim 19, wherein at least two additional side walls of the chamber have retro-reflective faces.

23. The apparatus of claim 19, wherein the ratio of the width the chamber to the thickness of the chamber is at least 4:1, and wherein the chamber has a thickness in the range of 0.5 to 2 mm.

24. The apparatus of claim 19, wherein the plates, thermal element, and optics system are incorporated into a heat-exchanging module, the apparatus further comprises a base instrument for receiving the heat-exchanging module, and the base instrument includes processing electronics for controlling the operation of the module.

25. The apparatus of claim 24, wherein the heat-exchanging module further comprises a housing and a cooling element disposed within the housing for cooling the reaction mixture contained in the chamber.

26. The apparatus of claim 24, wherein the base instrument is constructed to receive and control a plurality of such heat-exchanging modules.

27. The apparatus of claim 26, further comprising at least one computer for controlling the base instrument.

28. An apparatus for controlling the temperature of a reaction mixture contained in a reaction vessel, wherein the vessel includes a reaction chamber, a port, and a channel connecting the port to the chamber, and wherein the chamber has at least one flexible wall, the apparatus comprising:

a) at least one thermal surface for contacting the flexible wall;

b) an automated machine for increasing the pressure in the chamber, wherein the pressure increase in the chamber is sufficient to force the major wall to contact and conform to the thermal surface; and

c) at least one thermal element for heating or cooling the surface to induce a temperature change within the chamber.

29. The apparatus of claim 28, wherein the apparatus includes first and second thermal surfaces formed by opposing plates positioned to receive the chamber of the vessel between them, and wherein each of the plates has a heating element coupled thereto.

30. The apparatus of claim 29, wherein each of the plates comprises a ceramic material, and wherein each of the plates has a thickness less than or equal to 1 mm.

31. The apparatus of claim 29, wherein the heating element comprises a film.

32. The apparatus of claim 29, wherein each of the plates has a thermal mass less than 5 J/°C.

33. The apparatus of claim 29, wherein each of the plates has a thermal mass less than 3 J/°C.

34. The apparatus of claim 29, wherein each of the plates has a thermal mass less than 1 J/°C.

35. The apparatus of claim 29, further comprising a support structure for holding the plates in an opposing relationship to each other, the support structure comprising:

a) a mounting plate having a slot therein;

b) spacing posts extending from the mounting plate on opposite sides of the slot, wherein each of the spacing posts has indentations formed on opposite sides thereof for receiving the edges of the plates; and

c) retention clips for holding the edges of the plates in the indentations formed in the spacing posts.

36. The apparatus of claim 28, wherein the automated machine comprises a pick-and-place machine for inserting a plunger into the channel to compress gas in the vessel and thereby increase pressure in the chamber.

37. The apparatus of claim 28, wherein the automated machine comprises:

a) a machine head having an axial bore for communicating with the channel of the vessel; and

b) a pressure source for pressurizing the chamber through the bore in the machine head.

38. The apparatus of claim 37, further comprising an adapter for placing the bore in fluid communication with the channel, wherein the adapter is sized to be inserted into the channel such that the adapter establishes a seal with the walls of the channel.

39. The apparatus of claim 38, wherein the adapter includes a valve for preventing fluid from escaping from the vessel.

40. The apparatus of claim 28, wherein the apparatus further includes an elastomeric plug inserted into the channel of the vessel, and wherein the automated machine comprises:

a) means for inserting a needle through the plug; and

b) a pressure source for injecting fluid into the vessel through the needle.

41. The apparatus of claim 40, wherein the needle includes a first bore for dispensing the fluid into the vessel and a second bore for venting gas from the vessel, and wherein the first bore has a length greater than the second bore.

42. The apparatus of claim 28, wherein the automated machine comprises a platen for heat sealing a film or foil to the vessel to seal the port and reduce the volume of the channel.

43. The apparatus of claim 28, further comprising an optics system for optically interrogating the mixture contained in the chamber through first and second optically transmissive walls of the vessel, the optics system having at least one light source for exciting the mixture through the first wall and having at least one detector for detecting light emitted from the chamber through the second wall.

44. The apparatus of claim 43, wherein the plates, heating elements, and optics system are incorporated into a heat-exchanging module, the apparatus further comprises a base instrument for receiving the heat-exchanging module, and the base instrument includes processing electronics for controlling the operation of the module.

45. The apparatus of claim 44, wherein the heat-exchanging module further comprises a housing and a cooling element disposed within the housing for cooling the reaction mixture.

46. The apparatus of claim 44, wherein the base instrument is constructed to receive and control a plurality of such heat-exchanging modules.

47. The apparatus of claim 46, further comprising at least one computer for controlling the base instrument.

48. An apparatus for controlling the temperature of a reaction mixture contained in a reaction vessel, wherein the vessel includes a chamber for holding the mixture, the apparatus comprising:

a) opposing plates positioned to receive the chamber of the vessel between them;

b) a support structure for holding the plates in an opposing relationship to each other, the support structure comprising:

i) a mounting plate having a slot therein;

ii) spacing posts extending from the mounting plate on opposite sides of the slot, wherein each of the spacing posts has indentations formed on opposite sides thereof for receiving edges of the plates; and

iii) retention means for holding the edges of the plates in the indentations formed in the spacing posts; and

c) at least one thermal element for heating or cooling the plates to induce a temperature change within the chamber.

49. The apparatus of claim 48, wherein each of the plates comprises a ceramic material, and wherein each of the plates has a resistive heating element coupled thereto.

50. The apparatus of claim 49, wherein the heating element comprises a film.

51. The apparatus of claim 48, wherein each of the plates has a thermal mass less than 5 J/°C.

52. The apparatus of claim 48, wherein each of the plates has a thermal mass less than 3 J/°C.

53. The apparatus of claim 48, wherein each of the plates has a thermal mass less than 1 J/°C.

54. The apparatus of claim 48, wherein

a) the inner surfaces of the plates are angled towards each other so that, prior to insertion of the chamber between the plates, the bottoms of the plates are closer to each other than the tops of the plates;

b) the bottoms of the plates are initially spaced a distance from each other that is less than the thickness of the chamber; and

c) the retention means comprises retention clips for holding the plates in the indentations formed in the spacing posts, the retention clips being sufficiently flexible to accommodate an outward movement of the plates when the chamber of the vessel is inserted between them.

55. The apparatus of claim 54, further comprising stops for preventing the plates from spreading farther than a predetermined maximum distance from each other.

56. The apparatus of claim 48, further comprising means for increasing the pressure in the chamber, wherein the pressure increase is sufficient to force the walls of the chamber to contact and conform to the inner surfaces of the plates.

57. The apparatus of claim 56, wherein the vessel includes a port and a channel connecting the port to the chamber, and wherein the means for increasing the pressure in the chamber comprises a plunger that is inserted into the channel to compress gas in the vessel.

58. The apparatus of claim 57, wherein the plunger has a pressure stroke sufficient to increase pressure in the chamber to at least 2 psi above the ambient pressure external to the vessel.

59. The apparatus of claim 56, wherein the vessel includes a port and a channel connecting the port to the chamber, and wherein the means for increasing the pressure in the chamber comprises:

a) a machine head having an axial bore for communicating with the channel of the vessel; and

b) a pressure source for pressurizing the chamber through the bore in the machine head.

60. The apparatus of claim 59, further comprising an adapter for placing the bore in fluid communication with the channel, wherein the adapter is sized to be inserted into the channel such that the adapter establishes a seal with the walls of the channel.

61. The apparatus of claim 60, wherein the adapter includes a valve for preventing fluid from escaping from the vessel.

62. The apparatus of claim 56, wherein the vessel includes a port and a channel connecting the port to the chamber, and wherein the means for increasing pressure in the chamber comprises;

a) an elastomeric plug inserted into the channel;

b) means for inserting a needle through the plug; and

c) a pressure source for injecting fluid into the vessel through the needle.

63. The apparatus of claim 56, wherein the vessel includes a port and a channel connecting the port to the chamber, and wherein the means for increasing pressure in the chamber comprises a platen for heat sealing a film or foil to the port, thereby sealing the port and reducing the volume of the channel.

64. The apparatus of claim 48, further comprising at least one controller for controlling the operation of the thermal element.

65. A reaction vessel comprising:

a) a rigid frame defining the side walls of a chamber, wherein the frame further includes a port and a channel connecting the port to the chamber;

b) at least one flexible sheet attached to the rigid frame to form a major wall of the chamber; and

c) a plunger that may be inserted into the channel to compress gas in the vessel, thereby increasing pressure in the chamber and outwardly expanding the major wall, wherein the frame includes an inner surface defining the channel, and wherein the inner surface has at least one pressure control groove formed therein, the groove extending to a predetermined depth in the channel to allow gas to escape from the channel until the plunger is inserted to the predetermined depth.

66. The vessel of claim 65, wherein the vessel includes first and second flexible sheets attached to opposite sides of the rigid frame to form opposing major walls of the chamber, and wherein each of the major walls is sufficiently flexible to conform to a respective thermal surface.

67. The vessel of claim 65, wherein the plunger comprises:

a) a stem;

b) a piston on the stem for compressing the gas; and

c) an alignment ring encircling the stem for maintaining the plunger in a substantially coaxial alignment with the channel as the plunger is inserted into the channel.

68. The vessel of claim 67, wherein the stem terminates in a tongue, and wherein the stem has a length substantially equal to the length of the channel so that the tip of the tongue is positioned at the end of the channel adjacent an entrance to the chamber when the plunger is fully inserted into the channel.

69. The vessel of claim 65, wherein the plunger has a pressure stroke sufficient to increase pressure in the chamber to at least 2 psi above the ambient pressure external to the vessel.

70. The vessel of claim 69, wherein the pressure stroke is sufficient to increase pressure in the chamber to a pressure in the range of 8 to 15 psi above the ambient pressure.

71. The vessel of claim 65, wherein the plunger has a plunger cap having an engagement aperture for receiving and establishing a fit with a machine tip, thereby enabling the machine tip to pick and place the plunger into the channel.

72. The vessel of claim 65, wherein the plunger includes a plunger cap having a snap ring, and wherein the vessel includes an annular recess encircling the port for receiving the snap ring.

73. The vessel of claim 65, wherein at least two of the side walls of the chamber are optically transmissive and angularly offset from each other by about 90°.

74. The vessel of claim 73, wherein at least two additional side walls of the chamber have retro-reflective faces.

75. The vessel of claim 65, wherein the ratio of the width of the chamber to the thickness of the chamber is at least 4:1, and wherein the chamber has a thickness in the range of 0.5 to 2 mm.

76. The vessel of claim 65, further comprising dried or lyophilized reagents in the chamber.

77. A reaction vessel comprising:

a) a rigid frame defining the side walls of a chamber, wherein the frame further includes a port and a channel connecting the port to the chamber;

b) at least one flexible sheet attached to the rigid frame to form a major wall of the chamber; and

c) a plunger that is inserted into the channel to compress gas in the vessel, thereby increasing pressure in the chamber and outwardly expanding the major wall, wherein the plunger comprises:

i) a stem;

ii) a piston on the stem for compressing the gas; and

iii) an alignment ring encircling the stem for maintaining the plunger in a substantially coaxial alignment with the channel as the plunger is inserted into the channel.

78. The vessel of claim 77, wherein the vessel includes first and second flexible sheets attached to opposite sides of the rigid frame to form opposing major walls of the chamber, and wherein each of the major walls is sufficiently flexible to conform to a respective thermal surface.

79. The vessel of claim 77, wherein the frame includes an inner surface defining the channel, and wherein the inner surface has at least one pressure control groove formed therein, the groove extending to a predetermined depth in the channel to allow the gas to escape from the channel until the piston reaches the predetermined depth.

80. The vessel of claim 77, wherein the plunger has a pressure stroke sufficient to increase pressure in the chamber to at least 2 psi above the ambient pressure external to the vessel.

81. The vessel of claim 80, wherein the pressure stroke is sufficient to increase pressure in the chamber to a pressure in the range of 8 to 15 psi above the ambient pressure.

82. The vessel of claim 77, wherein the plunger has a plunger cap having an engagement aperture for receiving and establishing a fit with a machine tip, thereby enabling the machine tip to pick and place the plunger into the channel.

83. The vessel of claim 77, wherein the plunger includes a plunger cap having a snap ring, and wherein the vessel includes an annular recess encircling the port for receiving the snap ring.

84. The vessel of claim 77, wherein at least two of the side walls of the chamber are optically transmissive and angularly offset from each other by about 90°.

85. The vessel of claim 84, wherein at least two additional side walls of the chamber have retro-reflective faces.

86. The vessel of claim 77, wherein the ratio of the width of the chamber to the thickness of the chamber is at least 4:1, and wherein the chamber has a thickness in the range of 0.5 to 2 mm.

87. The vessel of claim 77, further comprising dried or lyophilized reagents in the chamber.

88. A reaction vessel comprising:

a) a rigid frame defining the side walls of a chamber, wherein the frame further includes a port and a channel connecting the port to the chamber;

b) at least one flexible sheet attached to the rigid frame to form a major wall of the chamber; and

c) a plunger that may be inserted into the channel to compress gas in the vessel, thereby increasing pressure in the chamber and outwardly expanding the major wall, wherein the plunger comprises a stem and an elastomeric ring encircling the stem for establishing a seal with the walls of the channel.

89. The vessel of claim 88, wherein the vessel includes first and second flexible sheets attached to opposite sides of the rigid frame to form opposing major walls of the chamber, and wherein each of the major walls is sufficiently flexible to conform to a respective thermal surface.

90. The vessel of claim 88, wherein the plunger further includes two flanges extending radially from the stem, and wherein the flanges are positioned on opposite sides of the ring to hold the ring in a substantially fixed position on the stem.

91. The vessel of claim 88, wherein the plunger has a pressure stroke sufficient to increase pressure in the chamber to at least 2 psi above the ambient pressure external to the vessel.

92. The vessel of claim 91, wherein the pressure stroke is sufficient to increase pressure in the chamber to a pressure in the range of 8 to 15 psi above the ambient pressure.

93. The vessel of claim 88, wherein the plunger includes a plunger cap having a snap ring, and wherein the vessel includes an annular recess encircling the port for receiving the snap ring.

94. The vessel of claim 88, wherein at least two of the side walls of the chamber are optically transmissive and angularly offset from each other by about 90°.

95. The vessel of claim 94, wherein at least two additional side walls of the chamber have retro-reflective faces.

96. The vessel of claim 88, wherein the ratio of the width of the chamber to the thickness of the chamber is at least 4:1, and wherein the chamber has a thickness in the range of 0.5 to 2 mm.

97. The vessel of claim 88, further comprising dried or lyophilized reagents in the chamber.